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United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

THE WHITE-FRINGED BEETLE, NAUPACTUS LEUCOLOMA BOH. 1/

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Introduction

The first report of the appearance of the white-fringed beetle in the United States was made by the Division of Insect Identification in the Bureau News Letter dated September 1, 1936, when it was reported that L. L. Buchanan had identified as Naupactus leucoloma Boh. two specimens received from A. N. Tissot, of the Florida Agricultural Experiment Station. These beetles came from the area around Svea, Okaloosa County, Fla., and at that time were reported to be injuring peanuts. In the October 1, 1936, issue of the Insect Pest Survey Bulletin J. R. Watson reported that this insect had appeared during the summer in the northern part of Walton County, in western Florida, and in adjacent areas in Alabama, where it was causing much damage to peanuts and some injury to cotton and other plants.

J. R. Watson, of the Florida Agricultural Experiment Station, and U. C. Loftin, of the Bureau of Entomology and Plant Quarantine, made a brief survey of the infested area in Walton and Okaloosa Counties, Fla., on May 14, 1937, and an account of their observations is given in the Bureau News Letter dated June 1, 1937. At that time the larvae were reported attacking cotton, corn, peanuts, and velvetbeans.

This insect is a native of Argentina, Chile, and Uruguay, in South America, and has recently been discovered in New South Wales, Australia (Rev. App. Ent., vol. 21, p. 303, 1933), where it was "attacking the roots of lucerne."

The research upon which this paper is based was started at Florala, Ala., on June 23, 1937. This work has been under way for too short a period to cover all phases of the life history, but a brief summary of the data secured prior to January 1, 1938, is presented herein.

1/ Order Coleoptera, family Curculionidae, subfamily Otiorhychinae, tribe Epicaerini.

Present Known Distribution in the United States

The largest known infested area centers around Florala, Ala., and lies in the States of Alabama and Florida. This area covers approximately 27 square miles. Smaller infestations have been found at Pensacola, Fla., Laurel, Miss., and New Orleans, La. The infestation at Pensacola includes 26 city blocks, and only a small number of specimens have been found there. At Laurel, Miss., infestation has been found over 1.1 square miles, and most of this area lies within the city limits. The infestation at New Orleans includes approximately one-third square mile and lies near the docks along the Mississippi River. All the adults found at New Orleans late in September were dead, but living larvae were found in this locality during November.

Another very similar species, which has been identified as Naupactus sp. and tentatively as a new species, was found in southern Mississippi. Infestations of this were found at Gulfport, Landon, and Saucier in Harrison County, and at McHenry in Stone County. The feeding signs of the adult are very similar to those of the white-fringed beetle.

Stages of the White-Fringed Beetle

The adult

Description.--The adult beetle (fig. 1, A and B) is seven-sixteenths of an inch in length and about five thirty-seconds of an inch across the abdomen. The color is dark gray, with a lighter band along the margins of the elytra, and two paler longitudinal lines on each side of the thorax and head (one above and one below the eye, fig. 1, A). The body is densely covered with pale hairs, which are especially long on the elytra. The underwings are present but very rudimentary and vary greatly in size with the individual beetles. The elytra are fused together, and the adults are incapable of flight.

Activities of the adults.--In 1937 the adults began to emerge about June 15, but according to farmers in the Florala area none was seen in 1936 until July 1. The peak of emergence was reached between July 7 and July 11. After emerging, the adults crawl to the nearest favorite host plant to feed and pass the preoviposition period. On cotton plants they congregate in clusters near the terminal buds but usually on the underside of the leaves. In peanuts the beetles are usually found on the lower part of the vines near the surface of the soil. Beetles in corn that is not intercropped with velvetbeans or peanuts migrate therefrom in search of other food.

After several days of feeding the beetles begin gradually to disseminate over the plants. When ready to deposit eggs the beetles have become well distributed over the plants, either individually or in small clusters. The ground activity is very limited until egg deposition commences, provided favorite host plants are present. The beetles confine their feeding to the outer margin of the leaves, usually the portion of leaf nearest the petiole. They prefer the older leaves of all plants rather than the tender buds. They feed often but consume no great quantity

leaf surface. On cotton plants 30 inches in height, where 100 to 200 beetles fed for 6 to 10 days, less than 50 percent of the leaf surface was consumed. On velvetbeans, 100 to 150 beetles have been observed to feed for several weeks without consuming more than 25 percent of the leaf surface. In a few instances where peanuts adjoined heavily infested cornfields the adjacent rows of peanuts have been totally stripped by the hordes of migrating beetles.

Observations made at various hours during the day and night showed less activity at night than during daylight. After egg depositions begins, the beetles feed and rest on the lower parts of the plants. The period of greatest activity is from 1 p. m. to 4:30 p. m.

After the beetles have passed the preoviposition period they leave the plants to deposit eggs. At the end of each day's activity they come to rest on the lower portion of a plant or may rest on the ground if there is sufficient cover of grass or weeds to conceal them. The migration is more or less a gradual dissemination away from the areas where they emerged or passed the preoviposition period. The beetles do not move any great distance per day but gradually keep moving in the same general direction day after day. The seasonal movement covered from one-fourth to three-fourths mile, depending on the type of vegetation in the path of the beetles. The movement is greatest over areas bearing scant vegetation and less over areas covered with dense vegetation. The beetle's habit of investigating practically every plant in its path prevents it from moving any great distance.

Parthenogenesis.--So far as is known there are no males. This insect reproduces parthenogenetically. Dissection of more than 2,300 adults collected in the field in the Florala area showed that all the individuals were female. Thirty-two beetles were reared from larvae or pupae in the insectary and were confined separately from the day of emergence in small jelly glasses with soil and foliage. Every one of these individuals deposited fertile eggs.

Abundance of adults.--In a heavily infested cotton field one man collected approximately 80,000 beetles from one-half acre in 4 hours on July 14. As the bag-and-hoop method was used for collecting the beetles shaken from the plants and only about two-thirds of the beetles were captured, they were present at the rate of about 240,000 per acre. The average population was 48 beetles per plant. Approximately 50 percent of the plants in this field had been destroyed by the larvae, and the stand was only 5,000 plants per acre.

During the period immediately after emergence, July 7 to July 20, it was common to find from 50 to 100 beetles per plant in the infested cotton fields, and from 150 to 200 beetles were taken from individual plants in the heavily infested portions of cotton fields. On July 10, 250 beetles were taken from one cotton plant, 78 from one velvetbean plant, and 44 from one peanut plant. As late as September 6, 226 beetles were collected from one cocklebur plant, 188 from one velvetbean plant, and 30 from one cotton plant.

The seasonal decrease in the abundance of adults was checked during the fall by making daily counts of the number trapped in designated sections of a barrier trench surrounding a corn and velvetbean field. During the period of September 20-24 a total of 1,037 beetles were caught. The number captured decreased to 213 for the period of October 10-14 and to 130 for the period of October 30-November 3. Only 24 beetles were captured during the period of November 9-13 and 2 during the period of November 19-23. The last beetle captured in the sections of the trench under observation was taken on December 5; however, living beetles were found as late as December 18.

Preoviposition period.--The average preoviposition period for 32 individuals reared in the insectary was 11.4 days; the periods ranged from 4 to 37 days. These beetles were fed on cotton or peanut foliage.

Oviposition records.--Complete oviposition records were secured from 32 beetles which were reared in the insectary. A total of 25,302 eggs were deposited by these 32 beetles, ranging from 83 to 1,847 eggs per beetle, with an average of 790.7. The greatest number laid by any one beetle in one day was 137, and the daily average was 9.2 eggs per living beetle. These beetles emerged from July 10 to July 31, and the egg-deposition period ranged from July 15 to November 29. Ten of the 32 beetles deposited more than 1,000 eggs each.

Partial oviposition records were secured for 40 field-collected beetles. These beetles were not collected until July 20, consequently only a partial record was secured, since adults were already depositing eggs under field conditions. These 40 beetles deposited a total of 20,496 eggs, or an average of 512.4 per beetle. The egg-deposition period extended to November 29, and the last beetle died on December 4. The daily average was 9.8 eggs per living beetle.

Postoviposition period.--The average length of life after depositing the last eggs was 13.6 days. A few beetles deposited eggs on the date they died, but the majority lived for a week or more after egg laying ceased.

Length of life of adults.--The average length of life for 32 beetles kept under insectary conditions was 96.9 days. The total length of life was divided as follows: Preoviposition period 11.4 days, oviposition period 71.9 days, and postoviposition period 13.6 days. The maximum length of life was 147 days for a beetle which emerged on July 21 and died on December 15.

The effect of no food and of different foods on the longevity of adults.--Newly emerged beetles kept without food did not deposit eggs. The average longevity was 13.8 days and the maximum was 46 days.

The available food plants affect the length of life of the adults. On August 2, 160 beetles were collected at random from a cotton field; 40 were fed on peanut foliage, 40 on cotton foliage, 40 on grass, and 40 were kept on moist soil but without food. The beetles kept without food lived only a short period. The average longevity was 8.2 days and

the maximum was 12 days. The average longevity of the beetles fed on grass, cotton, and peanut foliage was 17.2, 32.8, and 47.5 days, respectively. The maximum longevity of the beetles fed on grass, cotton, and peanut foliage was 44, 129, and 131 days, respectively.

Another series of adults were collected on August 4 in an abandoned field where they had been feeding on wild host plants, which consisted mostly of blackberry bushes. These beetles were divided into two lots, one lot being fed on cotton foliage and the other on blackberry foliage. The average longevity of the beetles fed on cotton was 33.4 days, and the maximum was 122 days. The average longevity of those fed on blackberry foliage was 26.1 days, and the maximum was 81 days. The beetles fed on blackberry foliage did not live as long as those fed on cotton but they lived considerably longer than those fed on grass.

The egg

The egg (fig. 1, C) is approximately 0.9 mm long and 0.6 mm wide, and is oval in shape. The color when freshly deposited is milky white; the color changes to dull light yellow after 4 or 5 days.

The eggs are deposited in masses, ranging in number from a few to as high as 60 or more, but the usual number is from 15 to 25. The individual eggs and masses are covered with a gelatinous substance which makes them adhere to one another and to objects or the soil.

Place of deposition.--The eggs are deposited at the point of contact between soil and objects such as sticks, gravel, plant stems, and other things lying on or protruding from the ground. In some instances, where the soil is easily penetrated by the ovipositor, eggs are deposited directly in the soil. The depth of the eggs in the soil ranged from one-sixteenth to five-sixteenths inch. In a few instances egg masses have been found on plants as much as 1-1/2 inches above the surface of the soil. Egg masses have been found on cotton bolls, seed cotton, pecans, maypops, and corn husks where they were in contact with the soil. In fields cropped to cotton the previous year, the parts of the old stalks that are partially covered with soil seem to be favorite places for egg deposition. In peanuts and Mexican-clover the egg masses are often found attached to the underside of the stems where they are in contact with the soil. The beetle prefers to deposit eggs in shaded places beneath plants, but the greatest egg-laying activity occurs between 1 and 4:30 p. m., i. e., usually during the warmest part of the day.

Duration of the egg stage.--Eggs were removed from the jelly glasses where deposited in the laboratory and placed in metal salve boxes on moist blotting paper for incubation records. A few drops of water were added as needed to keep the blotting paper moist throughout the incubation period.

The incubation periods for eggs deposited from July 15 to September 2 averaged 14.3 days, and 85.5 percent of the eggs hatched on the 12th to the 15th day inclusive. After September 2 the incubation period increased. The average incubation period for eggs deposited from

September 3 to September 12 was 18 days; September 13 to September 23, 20 days; September 23 to October 2, 23.3 days; and October 3 to October 12, 41 days. Complete incubation records are not available at present (January 10) for eggs deposited after September 25. Eggs deposited after this date have hatched very slowly, many requiring more than 60 days.

The incubation periods for 13,766 eggs deposited from July 15 through October 12 are given in table 1.

Table 1.--Average length, in days, of the incubation period for eggs of the white-fringed beetle deposited on the dates given

Date eggs were deposited	Number of eggs	Incubation period (days)
July 15-24	1,988	15.1
July 25-Aug. 3	3,128	13.4
Aug. 4-13	1,763	14.3
Aug.14-23	753	16.0
Aug.24-Sept.2	887	16.5
Sept.3-12	1,822	18.0
Sept.13-22	1,163	20.0
Sept.23-Oct 2*	1,031	23.3
Oct 3-12*	1,231	41.0

*Incubation periods incomplete.

No larvae have emerged from eggs deposited prior to July 23, when the eggs were kept under dry conditions. As late as December 20 these eggs were still viable, as is shown by the fact that larvae emerged within 3 days after the eggs were placed under moist conditions at natural temperatures. Larvae emerged from these eggs within 3 hours after they were placed under moist condition at a temperature of 70° to 80° F. The larvae within such eggs are fully developed. Apparently moist conditions are not necessary for the development of the larva within the egg. The moist conditions which are apparently necessary for the emergence of the larvae from the eggs also cool and soften the soil, making it favorable for the newly emerged larvae.

The larva

Description.--The full-grown larva (fig. 1, D) 2/ averages approximately one-half inch in length. The body is yellowish white, fleshy,

2/ The illustration, lateral view, of the larva (fig. 1, D) was made from a specimen preserved in fluid and is an accurate representation of that specimen. The foregoing description was made from living larvae, and any discrepancies between it and the drawing are due to distortion in the preserved material.

more or less curved, legless, and sparsely covered with hair. It consists of 12 much-folded segments, which are interrupted by two sublateral longitudinal grooves running the length of the body. The dorsal portions of the segments are bulging; the ventral portions are flat. On the sides, above the longitudinal separating grooves, small spiracles are present on all segments except the second, third, and twelfth (last).

Feeding habits of the larvae and the injury they cause.--The principal damage is caused by the larvae feeding on the roots of the young plants in the spring. The lower part of the stem and taproot are chewed away, but the smaller lateral roots are not attacked. In many instances the larvae burrow into the seed and devour the contents before the young plant has had sufficient time to appear above the ground.

On most plants such as cotton, velvetbeans, peanuts, field peas, and sweetpotatoes the larvae consume the fleshy portion of the underground stem and taproot, usually leaving the tougher central portion. Only occasionally is the stem or root completely severed and then only in the case of very young plants. On larger plants the larvae may feed only on one side of the root and then for only several inches.

The feeding on corn and sugarcane is somewhat different from that on other plants. On these plants the larva cuts a small hole one-fourth to one-half inch in diameter into the main stem, usually burrowing one-fourth to one-half inch into the stem, but has never been observed tunneling along the root for more than 1 inch.

The major portion of the feeding on roots during the spring extends from the surface of the ground to a depth of 6 inches. Where the feeding is severe the plants turn yellow, wilt, and die. Where only a small section of the cambium layer is eaten away the plants survive but produce very little or no crop. The larvae undoubtedly feed at greater depths during the summer as the root systems of plants extend downward.

The larvae are very general feeders and caused serious injury to field and garden crops in the Florala area during 1937. The infestations are still localized on many farms, but the yields were materially reduced in many fields. In some fields as high as 90 percent of the plants were killed in areas ranging from a few square yards to an acre or more. In many instances, after the larvae had destroyed the stand, the fields were replanted and the larvae then destroyed the second planting. In heavily infested spots the larvae not only killed the cultivated crops but also the grass and weeds. Late in June and early in July these spots were barren and could easily be detected at great distances. After the greater number of the larvae matured and emerged as adults, a heavy growth of grass developed on the former barren areas.

The larval injury to peanuts occurs at two distinct periods. At planting time and shortly thereafter the larvae feed on the planted seed and on the roots of the young plants, thereby damaging the stand. The adults after emerging concentrate on the remaining plants and deposit

eggs in the area immediately surrounding the plants. Later in the season the newly emerged and older larvae attack the developing nuts, chewing away portions of the hulls, and often boring through the hull and destroying the kernel. The nuts of chufa are injured in the same manner as are those of peanuts.

During the fall larvae have been observed feeding on the underground stems and taproots of cowpeas and peanuts after these plants had matured and died or had been killed by frost. Evidently the decaying roots furnish a desirable food for the larvae. In one field the soil from around 96 cowpea plants was examined, and an average of 16.6 larvae per plant was found. An area 4 inches in diameter around each plant was examined to a depth of 6 inches.

Larval development.--Newly hatched larvae were found in the fields on July 27, and it is highly probable that some new larvae emerged several weeks previously. There were many larvae in the soil during July that appeared to be fully matured but which did not pupate, and no pupae were found after August 1. These large larvae were active throughout the summer, feeding principally on Mexican clover, but during the fall they fed very lightly when compared with larvae that hatched during July and August 1937. No reason is known for this carry-over of apparently mature larvae, and the maximum and minimum length of the life cycle is still to be determined.

The newly emerged larvae are capable of living for a long period without food. On August 13, 197 newly emerged larvae were confined in salve boxes without food, soil, or moisture. The average length of life for these larvae was 24.2 days. On September 1, or 19 days after hatching, 49.7 percent were alive. One month after hatching 29.4 percent were alive. The last larvae lived through October 24, or 73 days.

The larvae are not entirely dependent upon plant roots for development, at least during the early stages. Larvae hatched during August have been kept in sifted soil and have developed in size as well as other larvae that were provided with plant roots. It has not been determined whether larvae can develop to maturity without feeding on plant roots.

Vertical distribution of larvae in the soil.--In order to determine the distribution of the larvae in the soil, diggings are being made in infested fields at intervals. The larvae are removed from the soil by a combination process involving washing through a series of screens and flotation in a heavy solution. It is realized that soil type, soil moisture, available food material, and possibly soil temperature, affect the vertical distribution of the larvae. Usually the distribution is the result of a combination of these factors. Because it is impossible, in the preliminary work, to separate the results of the diggings and to group them satisfactorily according to the factors involved, the vertical distribution of the larvae for all diggings made on or near a definite date are grouped together in table 2.

Table 2.--Vertical distribution of white-fringed beetle larvae in the soil

Depth (inches)	Accumulative percentage of white-fringed beetle larvae found at different depths in the soil					
	Oct. 8-15	Oct. 20-21	Nov. 9	Nov. 22	Dec. 10	Dec. 21
1-3	27.8	24.3	50.0	50.0	43.5	42.3
1-6	70.4	63.6	77.6	83.0	75.8	84.6
1-9	88.9	79.3	90.8	91.0	91.9	92.3
1-12	95.4	86.4	94.7	95.0	98.4	96.2
1-15	95.4	92.8	98.7	99.0	100.0	98.1
1-18	98.2	97.1	98.7	99.0		98.1
1-21	99.1	100.0	100.0	99.0		100.0
1-24	100.0			100.0		
Mean depth (inches)	5.25	6.19	4.18	4.02	4.21	4.15
No. of larvae in sample	108	140	76	100	62	52

The mean depth during October ranged from 5.25 to 6.19 inches, but it was fairly constant during November and December, when the range was from 4.02 to 4.21 inches. In the diggings made during November and December from 94.7 percent to 98.4 percent of the larvae were in the upper 12 inches of soil and more than 90 percent were in the upper 9 inches. The percentage of the total number of larvae in the upper 9 inches during October ranged from 88.9 to 79.3. Larvae have been taken in the layer of soil 21 to 24 inches below the surface.

Larval population.--During November and December larval-population counts were made in a number of fields throughout the Florala area. The results have been grouped according to the crop grown in 1937 and are presented in table 3.

Table 3.--Larval population of the white-fringed beetle in 41 fields planted to various crops, Florala, Ala., November and December 1937.

Crop	Number of fields	Number of larvae per square yard	
		Range	Average
Cotton	13	8-718	147
Corn	5	0-103	41
Peanuts	12	0-1,041	283
Cotton (intercropped)	1		44
Corn (intercropped)	10	0-660	198
Average		0-1,041	184

Forty-one fields were sampled, and 5 of these showed no infestation. The number of larvae per square yard in the infested fields ranged from 8 to 1,041, or from 38,720 to 5,038,440 per acre. The average population in 13 cotton fields was 147 larvae per square yard; in 12 peanut fields, 283 larvae per square yard; in corn fields which were intercropped with velvetbeans or peanuts, 198 larvae per square yard; and in 5 corn fields which were not intercropped, 41 larvae per square yard.

The pupa

The pupa (fig. 1, E) is approximately seven-sixteenths inch in length, and when first formed is white. Parts of the body and appendages darken somewhat before transformation.

Just before pupation the larva prepares a neat earthen cell and lines it with a secretion from the body. It pupates mostly from 3 to 6 inches below the soil surface, and the pupal cell is approximately three to four times as large as the pupa. The longitudinal axis of the pupal chamber is on an inclined plane, and the exit tunnel is usually cut at approximately the same angle until the adult is within 1 inch of the surface and then it usually makes the exit hole perpendicular to the surface.

The date when pupation begins has not been ascertained. Loftin and Watson did not find any pupae in the area around Svea, Fla., on May 14; pupae were abundant, however, on June 23 and a few adults had already emerged on that date. Most of the adults had emerged by July 15, but an occasional pupa could be found during the last part of July. No pupae were found after August 1.

Host Plants of the Adults

During the short time this insect has been under investigation the adults have been observed in nature feeding on more than 50 kinds of plants. These include field, garden, and truck crops; weeds; ornamental flowers and shrubs; wild bushes, trees, and vines. The most common host plants are as follows: Velvetbean, cotton, peanut, lespedeza, lima bean, sweetpotato, okra, four-o'clock, beautyberry, wild petunia, myrtle, beggarweed, ragweed, cocklebur, teaweed or ironweed, coffeeweed, wild crotalaria, false-indigo, partridge-pea, ground-itch weed, maypop, wild morningglory, careless-weed, evening primrose, Mexican-clover, styptic-weed, mintweed, dollar-weed, hawthorn, gallberry, pecan, hackberry, black gum, poplar, blackjack oak, camphor, sassafras, wild grapevine, honeysuckle, greenbrier, kudzu, dewberry, and blackberry.

In the insectary the adults have been forced to feed on grasses, but their life span was much less than when fed on such plants as peanut, cotton, and blackberry.

Host Plants of the Larvae

These investigations were not undertaken early enough in 1937 to permit a thorough check of the host plants of the larvae. Since there are many other soil insects and animals that cause similar damage, the list given here includes only the 20 plants on which actual feeding has been observed. These host plants are as follows: Corn, sugarcane, cowpea, chufa, cotton, velvetbean, peanut, cabbage, sweetpotato, collards, tomato paspalum, careless-weed, smartweed, teaweed or ironweed, carpet grass, honeysuckle, Mexican-clover, apple, and alligator grass.

Undoubtedly further investigations will greatly expand this larval host list, as farmers who have had several years of experience with this insect report that the larvae attack many plants that we have not yet had an opportunity to observe.

The Effect of Topography and Soil Type on Infestations

In the Florala area infestations occur not only in the cultivated fields but also in woodland, pastures, and abandoned farms. The host range of this insect is such that it is highly probable it can subsist and develop on wild host plants in pastures and woodland. Scouting records to December 31, 1937, in the Florala area, show infestation on 5,723 acres of cultivated land and 5,031 acres of noncultivated land.

Soil types seem to have had very little effect, since infestations of approximately equal intensity occurred on clay, loam, and sandy soils. To date the greatest damage has occurred on the higher well-drained portions of the infested fields.

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Economic Importance of the White-Fringed Beetle

Both the larvae and adults feed on a wide range of plants. As compared with the damage done by the larvae, the feeding of the adults on plant foliage is of minor importance. Where numerous, the adults

may cause serious injury to garden and ornamental plants. The larvae have caused serious damage to numerous field and garden crops. The damage is exceedingly serious to such crops as potatoes and peanuts, where not only the stand is injured but the product is either destroyed or lowered in grade. It is reasonable to assume that the larvae and adults will attack many plants that are widely grown in other sections but are not grown in the area now known to be infested.

If the amount of damage already done in the Florala area can be used as a valid criterion, it is apparent that the white-fringed beetle, if allowed to spread, may become a serious pest in many agricultural regions of the United States. Its large range of host plants renders control complicated.

Because of the habits of the beetle, it is easily disseminated through commerce and other artificial means. The eggs are deposited on many parts of plants that move in commerce and they remain viable for more than 5 months, hatching when favorable conditions occur. The larvae can be transported with products which carry small quantities of soil. The adults readily attach themselves to many objects that move in commerce. The importance of the parthenogenetic reproduction of the white-fringed beetle should not be overlooked, since it is possible for an infestation to be started from only one specimen of any stage. Once the beetle has established itself in an area, an enormous population may build up within a short time, since the lack of flight by the adult reduces the possibility of immediate widespread natural dissemination.

Suppressive Measures Employed Against the Beetle

On July 21 a special allotment was made available to the Bureau of Entomology and Plant Quarantine for the control and suppression of the white-fringed beetle, and the following day approximately 40 Federal and State inspectors and 200 laborers began an active campaign against the spread of this beetle. Within a few days this number was increased to over 60 inspectors and 400 laborers.

An intensive inspection was made of the Florala area, which was the only infested area known at that time. After this area was delimited, inspections were made at numerous ports and commercial centers in the States of Texas, Louisiana, Mississippi, Alabama, Florida, and Georgia. Localized infestations were found in Laurel, Miss., and vicinity, as well as in Pensacola, Fla., and New Orleans, La. During scouting activities beetles of the genus Naupactus, very similar in appearance and habits to Naupactus leucoloma, were discovered in Gulfport, Miss., and vicinity. No infestations have as yet been found in Georgia and Texas. The States of Alabama, Florida, Louisiana, and Mississippi have cooperated with the Bureau by furnishing personnel and other aid.

The infested areas in Alabama, in Mississippi, and in Walton and Okaloosa Counties, Fla., have been placed under rigid quarantines by the State authorities, and the movement of all products likely to convey the white-fringed beetle in any stage is restricted.

Approximately 175 miles of barrier ditch were constructed around individual infested fields, and an outside barrier trench approximately 150 miles long was constructed around the entire infestation in the Florala area. The purpose of these trenches was to trap the beetles and prevent their further spread to new territory.

The first trenches constructed around the fields were of the furrow type with sloping finely pulverized sides, like those commonly used for chinch bug control, with post holes 15 to 20 feet apart. Daily rains made it impossible to maintain effective furrow-type trenches. Trenches with vertical sides were found to be much more effective during rainy weather. These trenches were approximately 12 inches wide by 10 inches deep. The post holes were 8 to 10 inches deep, with about 2 inches of loose soil in the bottom. This loose soil served the following two purposes: (1) In the event of rain the inrushing water trapped the beetles in the mud, and (2) if dry weather and sunlight prevailed, the dust absorbed sufficient heat to kill the beetles. As an additional precaution against the escape of the beetle the post holes were sprayed with kerosene twice daily.

The outside barrier trench was constructed with a tractor plow pulled by a "35" caterpillar tractor followed by a "trench-conditioner" pulled by a team of mules. The tractor plow cut a furrow 14 inches wide by 12.5 inches deep. The "trench-conditioner" left a finished trench 16 inches wide by 10.5 inches deep with vertical, well-packed sides. This "trench-conditioner" was designed and built by the Bureau of Entomology and Plant Quarantine specifically for this job in order to eliminate the large amount of hand labor ordinarily required to make an efficient vertical-side trench. This machine replaced 50 laborers. Post holes were placed 15 to 20 feet apart in this outside barrier trench. The capacity of the tractor plow and "trench-conditioner" is approximately 10 miles of trench for an 8-hour day.

Wherever trench barriers crossed terraces or drains, trap holes were placed in positions to catch the beetles. The trenches, both field and outside, were patrolled daily, and repairs were made when necessary. The adult beetles within the business and residential sections of Florala and Lockhart, Ala., were hand picked and destroyed.

As a further precaution, the premises around and near lumberyards, sawmills, cotton gins, peanut-shelling mills, and other industrial sites were cleaned of grass and weeds. The railroads cooperated to the extent of keeping their yards and rights-of-way throughout the infested area free of grass and weeds. The counties cooperated by placing trench barriers on each side of the roads throughout the infested area.

At Laurel, Miss., and Pensacola, Fla., the cities cooperated in control measures by cleaning the vegetation from vacant lots and alleys within the infested area and also by erecting trench barriers in the alleys. The heaviest infested lots were burned over with weed burners. The railroads cleaned their yards and rights-of-way of weeds, bushes, and excessive grass.

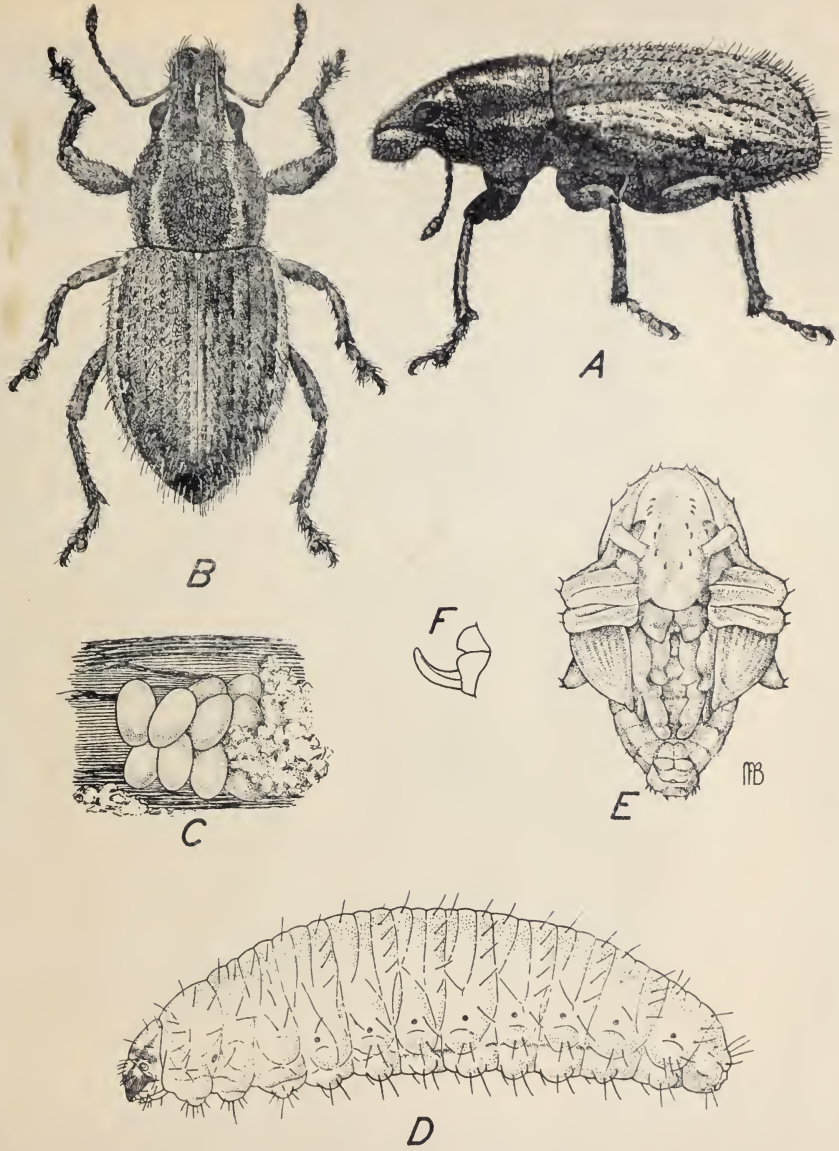

Figure 1.--The white-fringed beetle: A, adult beetle, lateral view; B, adult, dorsal view; C, cluster of eggs; D, full-grown larva, lateral view; E, pupa, ventral view; F, temporary cusp borne on mandible of newly emerged adult, lateral view. All greatly enlarged. (Original.)

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